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The Correlation between Plastron Thickness, Achieved Slip Length and Surface Wettability over Various Hydrophobic/Oleophilic Surfaces in Taylor-Couette Flows

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ABSTRACT

This study aims to use a statistical method to analyze the experimental data and investigate the relationship between the air plastron thickness and the slip length (as independent variables) and the Re number, shear stress, viscous ratio, and surface hydrophobicity (as dependent variables). In addition to the flow and fluid parameters, the contact angle (***CA***), which illustrates the surface hydro/oleophobicity, directly impacts the viscous drag over the investigated surfaces. Air layer thickness (plastron), which traps between the liquid and the substrate, and slip length are key factors in the achieved drag reduction. The plastron is generally linked with a non-wetted Cassie-Baxter state. The plastron thickness is affected by the topography of the superhydrophobic surfaces; when it depleted, the surface shows a wetting Wenzel state. The effect of a superhydrophobic surface on flow is parametrized by the effective slip length, which is a property of the fluid/solid interface and can, in principle, vary in space. Rheometer measurements over nine fabricated surfaces and using three different liquids of different surface tensions were used in this study. The measured global torque was used to compute the passive drag reductions in the Taylor-Couette (***TC***) cell flows. The multiple linear regression (MLR) method is used to analyze the data using the statistical package for the social science (SPSS) software. Two correlations for the predicted slip length (b^+) and the predicted air plastron thickness (δ) are statistically formulated. In general, the predicted air plastron thickness and slip length have shown a reasonable agreement with the experimental data for all used surfaces and tested liquids. The sensitivity analysis for these correlations shows an acceptable coefficient of determination (R^2). The root mean square error (***RMSE***) for the correlations is found to be very low.